Design Patterns

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Program term 1.4

01 (wk-16)	abstract classes and interfaces
02 (wk-17)	Template Method pattern / Observer pattern
03 (wk-18)	'voorjaarsvakantie' (spring break)
04 (wk-19)	MVC pattern
05 (wk-20)	Strategy pattern / Adapter pattern
06 (wk-21)	Singleton pattern / State pattern
07 (wk-22)	Factory patterns
08 (wk-23)	repetition / practice exam

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09 (wk-24)	exam *(computer assignments)*
10 (wk-25)	*retakes (courses term 1.3)*
11 (wk-26)	*retakes (courses term 1.4)*

Template Method pattern

- *'Define the skeleton of an algorithm in an operation, deferring some steps to subclasses. Template method lets subclasses redefine certain steps of an algorithm without changing the algorithm's structure.'*

- 'Standard recipe with some specific steps'
- Global recipe/algorithm is always the same (in the base class), differences are implemented in the derived classes

Coffee …

```
public class Coffee
{
  public void PrepareRecipe() {
    BoilWater();
    BrewCoffeeGrinds();
    PourInCup();
    AddSugarAndMilk();
  }

  public void BoilWater() {
    Console.WriteLine("Boiling water");
  }

  public void BrewCoffeeGrinds() {
    Console.WriteLine("Dripping coffee through filter");
  }

  public void PourInCup() {
    Console.WriteLine("Pouring into cup");
  }

  public void AddSugarAndMilk() {
    Console.WriteLine("Adding sugar and milk");
  }
}
```

The recipe/algorithm for making coffee.

The algorithm (to make coffee) has four steps/methods:
1. boil water;
2. brew coffee grinds;
3. pour coffee in cup;
4. add sugar and milk;

… and tea

The recipe/algorithm for making tea.

The algorithm (to make tea) has four steps/methods:
1. boil water;
2. steep teabag;
3. pour tea in cup;
4. Add lemon;

```
public class Tea
{
  public void PrepareRecipe() {
    BoilWater();
    SteepTeaBag();
    PourInCup();
    AddLemon();
  }

  public void BoilWater() {
    Console.WriteLine("Boiling water");
  }

  public void SteepTeaBag() {
    Console.WriteLine("Steeping the tea");
  }

  public void PourInCup() {
    Console.WriteLine("Pouring into cup");
  }

  public void AddLemon() {
    Console.WriteLine("Adding Lemon");
  }
}
```

Coffee and tea, find the differences…

Duplicate code! How can we minimize this?!?

```
public class Coffee
{
  public void PrepareRecipe() {
    BoilWater();
    BrewCoffeeGrinds();
    PourInCup();
    AddSugarAndMilk();
  }

  public void BoilWater() {
    Console.WriteLine("Boiling water");
  }

  public void BrewCoffeeGrinds() {
    Console.WriteLine("Dripping coffee through filter");
  }

  public void PourInCup() {
    Console.WriteLine("Pouring into cup");
  }

  public void AddSugarAndMilk() {
    Console.WriteLine("Adding sugar and milk");
  }
}
```

```
public class Tea
{
  public void PrepareRecipe() {
    BoilWater();
    SteepTeaBag();
    PourInCup();
    AddLemon();
  }

  public void BoilWater() {
    Console.WriteLine("Boiling water");
  }

  public void SteepTeaBag() {
    Console.WriteLine("Steeping the tea");
  }

  public void PourInCup() {
    Console.WriteLine("Pouring into cup");
  }

  public void AddLemon() {
    Console.WriteLine("Adding Lemon");
  }
}
```

This is the template method, a fixed algorithm.

```
public abstract class CaffeineBeverage
{
  public void PrepareRecipe() {
    BoilWater();
    Brew();
    PourInCup();
    AddIngredients();
  }

  public void BoilWater() {
    Console.WriteLine("Boiling water");
  }

  public abstract void Brew();

  public void PourInCup() {
    Console.WriteLine("Pouring into cup");
  }

  public abstract void AddIngredients();
}
```

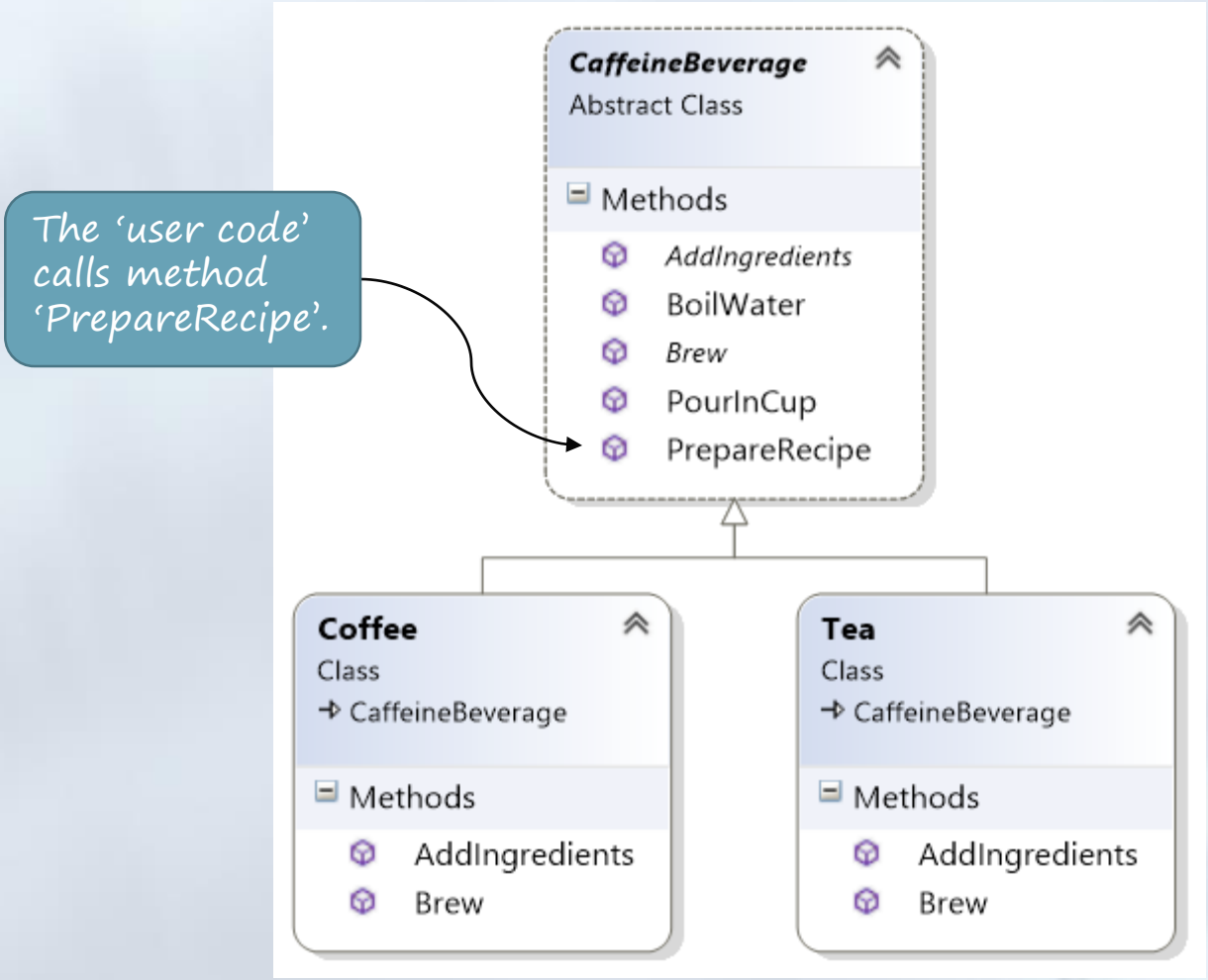
These 2 concrete methods are implemented by the base class itself.

These 2 abstract methods will be implemented by derived classes.

```
public class Coffee : CaffeineBeverage
{
  public override void Brew() {
    Console.WriteLine("Dripping coffee through filter");
  }

  public override void AddIngredients() {
    Console.WriteLine("Adding sugar and milk");
  }
}
```

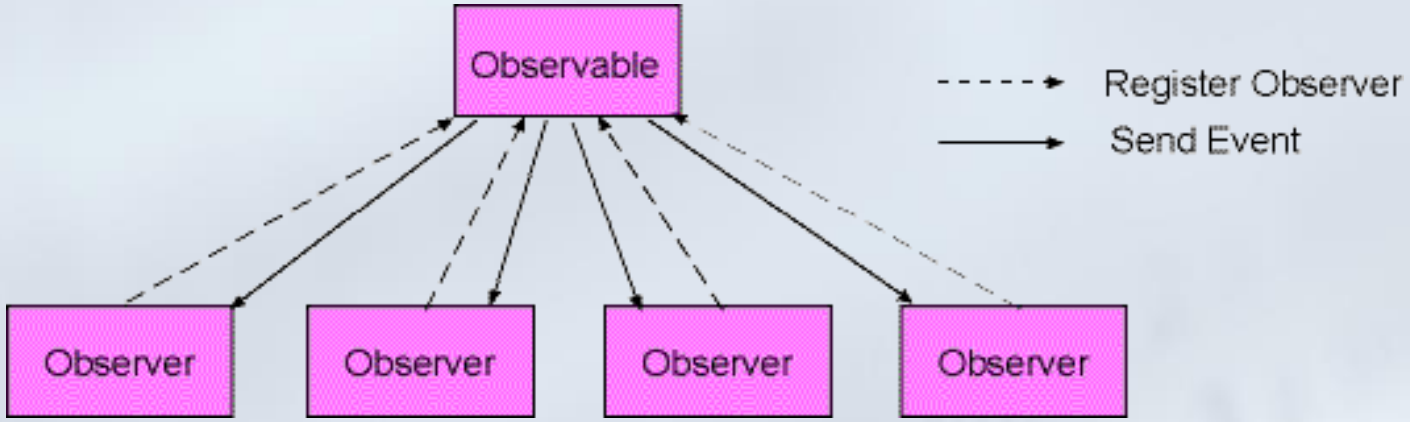
```
public class Tea : CaffeineBeverage
{
  public override void Brew() {
    Console.WriteLine("Steeping the tea");
  }

  public override void AddIngredients() {
    Console.WriteLine("Adding Lemon");
  }
}
```

Class diagram



Observer pattern

- Subject (Observable) ➔ sends updates
- Observers ➔ receives updates



Observer Method (GoF): *'Define a one-to-many dependency between objects so that when one object changes state, all its dependents are notified and updated automatically.'*

Example application

- Weather station (Subject/Observable)
- Multiple weather displays (Observers)

- The weather displays must be updated when a new measurement has been performed

'weather station'

'weather displays'

This is the information about the weather.

The weather displays are the observers; these will display the weather information.

All weather displays are being updated here.

What's wrong with this implementation?

```
public class WeatherStation
{
    public float Temperature { get; set; }
    public float Humidity { get; set; }
    public float Pressure { get; set; }

    private WeatherDisplay display1, display2;

    public WeatherStation(WeatherDisplay display1,
                          WeatherDisplay display2)
    {
        this.display1 = display1;
        this.display2 = display2;
    }

    public void MeasurementChanged() {
        // update weather information (read sensors)
        ReadTemperature();
        ReadHumidity();
        ReadPressure();

        // update all displays
        display1.Update(Temperature, Humidity, Pressure);
        display2.Update(Temperature, Humidity, Pressure);
    }

    // methods to read actual (sensor) values
    private void ReadTemperature() { }
    private void ReadHumidity() { }
    private void ReadPressure() { }
}
```

Make number of observers variable…

- Every weather display should be able to subscribe and unsubscribe itself for updates (to the weather station)

  (Observer: subscriber)

- The weather station has a list of subscribers (observers), and updates each weather display when a new measurement has been performed

  (Subject: publisher)

The weather displays are now variable; a dynamic list is used.

A weather display can subscribe/ unsubscribe.

All weather displays are updated here.

```
public class WeatherStation
{
  public float Temperature { get; set; }
  public float Humidity { get; set; }
  public float Pressure { get; set; }

  private List<WeatherDisplay> weatherDisplays = new List<WeatherDisplay>();

  public void RegisterObserver(WeatherDisplay display) {
          weatherDisplays.Add(display);
  }

  public void RemoveObserver(WeatherDisplay display) {
          weatherDisplays.Remove(display);
  }

  public void NotifyObservers() {
    foreach (WeatherDisplay display in this.weatherDisplays) {
      display.Update(Temperature, Humidity, Pressure);
    }
  }

  public void MeasurementChanged() {
    // update weather information (read sensors)
    ReadTemperature();
    ReadHumidity();
    ReadPressure();

    // update all displays
    NotifyObservers();
  }
```

Weather display

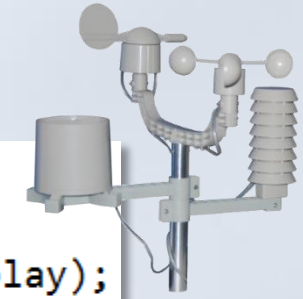
Observable is passed via constructor, and 'this' Observer subscribes itself.

This Update method will be called by the WeatherStation.

```
public class WeatherDisplay
{
  private WeatherStation weatherStation;

  public WeatherDisplay(WeatherStation weatherStation)
  {
    this.weatherStation = weatherStation;
    weatherStation.RegisterObserver(this);
  }

  public void Update(float temperature, float humidity, float pressure)
  {
    // display weather information
    Console.WriteLine(String.Format("T: {0}, H: {1}, P: {2}",
              temperature, humidity, pressure));
  }
}
```

Interfaces Observer pattern

- Usually an interface 'ISubject' is used for the Subject (WeatherStation)



```
public interface ISubject
{
  void RegisterObserver(IObserver display);
  void RemoveObserver(IObserver display);
  void NotifyObservers();
}
```

- Usually an interface 'IObserver' is used for Observer (WeatherDisplay)


```
public interface IObserver
{
  void Update(float temperature, float humidity, float pressure);
}
```

Weather display (IObserver)

WeatherDisplay is no longer linked to an specific class (WeatherStation) but to an interface (ISubject).

This means that a WeatherStation can be replaced by another 'ISubject'-object.


```
public class WeatherDisplay : IObserver
{
  private ISubject weatherStation;

  public WeatherDisplay(ISubject weatherStation)
  {
    this.weatherStation = weatherStation;
    weatherStation.RegisterObserver(this);
  }

  public void Update(float temperature, float humidity, float pressure)
  {
    // display weather information
    Console.WriteLine(String.Format("T: {0}, H: {1}, P: {2}",
              temperature, humidity, pressure));
  }
}
```

WeatherStation is no longer linked to a specific class (WeatherDisplay) but to an interface (IObserver).

This means that a WeatherDisplay can be replaced by another 'IObserver'-object.

```
public class WeatherStation : ISubject
{
  public float Temperature { get; set; }
  public float Humidity { get; set; }
  public float Pressure { get; set; }

  private List<IObserver> weatherDisplays = new List<IObserver>();

  public void RegisterObserver(IObserver display) {
          weatherDisplays.Add(display);
  }

  public void RemoveObserver(IObserver display) {
          weatherDisplays.Remove(display);
  }

  public void NotifyObservers() {
    foreach (IObserver display in this.weatherDisplays) {
      display.Update(Temperature, Humidity, Pressure);
    }
  }

  public void MeasurementChanged() {
    // update weather information (read sensors)
    ReadTemperature();
    ReadHumidity();
    ReadPressure();

    // update all displays
    NotifyObservers();
  }
```

Summary

- The 'Template Method' pattern defines a fixed algorithm in the base class, with some steps undefined, these steps must be implemented in derived classes

- The 'Observer' pattern creates a 'weak coupling' between 'state' objects (subjects) and 'listeners' (observers)

  (subject does not know who's listening…)

Assignments

- BlackBoard: ‘Week 2 assignments’